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691 N. Squirrel Road, Suite 111 • Auburn Hills, MI 48326
Phone: (248) 564-7852 • Fax: (248) 564-7925 • www.jpresearch.com

January 11, 2016

Mr. Neal Walters, Esq.
Ballard Spahr LLP
210 Lake Drive East
Suite 200
Cherry Hill, NJ 08002

Re: Keith Yaeger vs. Subaru of America, Inc.

Dear Mr. Walters:

At your request, I have performed an evaluation and analysis of technical issues related to the matter captioned Keith Yaeger vs. Subaru of America, Inc. Specifically, I was asked to review and analyze documents relating to the in use oil consumption of the Subaru FB engine family as well as address specific concerns that have been raised in this matter. My analysis is based upon the available information provided in this matter and my knowledge and experience in the fields of powertrain and chassis system design, performance, and operation, engine and powertrain testing and development, and on road vehicle performance evaluations.

My professional background includes testing and evaluation of both gasoline and diesel engines on dynamometers and in a variety of vehicle and equipment installations both on and off road. I have design and testing experience with two major automotive Original Equipment Manufacturers (OEM's) and am familiar with the operational characteristics and function of powertrain and chassis systems through testing and evaluating their operation in a wide range of environments and conditions across the United States and international markets. In addition, I have conducted numerous technical investigations to evaluate the performance of various engine, powertrain, and vehicle systems in a variety of duty cycles and environments as well as having investigated numerous on and off-road vehicle crashes. I have also served in the Chrysler Vehicle Safety Office working directly with the National Highway and Traffic Safety Administration (NHTSA) to investigate and resolve a variety of technical investigations. I am currently the instructor for SAE (Society of Automotive Engineers) Course C1344 Engine Failure Investigation and Analysis. A copy of my most current curriculum vitae is provided as an attachment. JP Research currently charges $230.00/hour for my services.

As part of my examination, I have reviewed the materials listed below. Based upon these materials, observations, and my experience described above, I have formed the opinions set forth below. The opinions presented here are held to a reasonable degree of

engineering certainty, and may be expanded based upon the receipt of any additional relevant material provided in this matter.

Materials Received Including:

Deposition Testimony and Exhibits:

- John Gray

Pleadings and Discovery Materials:

- Plaintiff's First Amended Complaint 9-17-14

Miscellaneous Materials:

- Document SOA12088-12098 (2013 Subaru G9 Service Technical Meeting)
- Document SOA12099-12103 (BF4 GOGI Mtg. #33)
- 2011-15 Subaru Forester Warranty Claims Records
- 2012-15 Subaru Impreza & Crosstrek XV Warranty Claims Records
- 2013-15 Subaru Legacy & Outback Warranty Claims Records

Issue Background and Description

In 2010 Subaru introduced their new FB engine platform to the North American market. This engine was similar to its predecessor the EJ platform in that it used the same horizontally opposed 4 cylinder or "boxer" layout but with numerous internal and external design differences. The FB engine was first offered in the 2011 model year Subaru Forester platform and subsequently offered in both 2.0L and 2.5L displacements in other Subaru product lines including the Legacy, Outback, Impreza, and XV Crosstrek models.

Subaru FB Engine

Following the introduction of the FB engine into the North American market, Subaru received a higher than anticipated number of warranty claims related to either engine oil consumption or oil level concerns in FB equipped vehicles. Subsequent review of these claims indicated that while most of them were simply due to the calibration and function of the oil level sensing system, a minority of the claims were the result of higher than anticipated engine oil consumption in certain FB engine equipped customer vehicles.

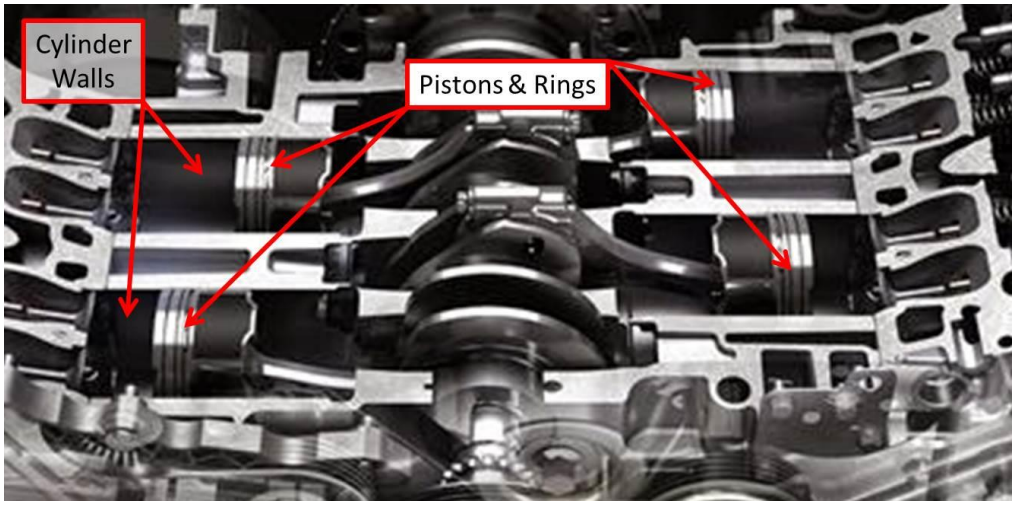
Investigation into the variations in engine oil consumption being reported and experienced by FB engine customers resulted in the implementation of several changes or countermeasures to the FB engine design and manufacturing process. These countermeasures, which affected the cylinder bore finish and piston rings, were implemented sequentially during the FB engine production process beginning in October of 2011.

Subsequent monitoring of FB engine oil consumption warranty claims during and since the incorporation of the countermeasures into the FB engine production has shown a significant reduction in oil consumption related claims rates back to a more typical minimal background level.

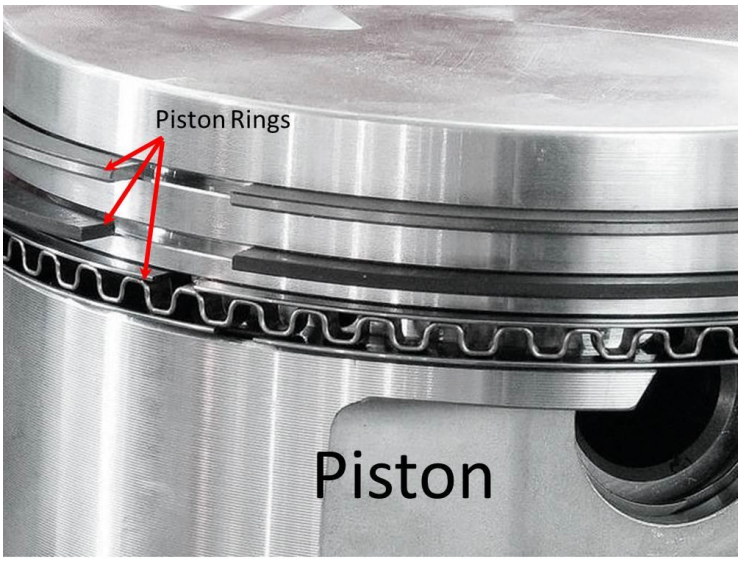
Engine Overview

Cylinder and Piston Rings

The Subaru FB engine, like most other modern automotive engines, is an internal combustion reciprocating piston engine in which a series pistons move back and forth inside their cylinder bores as the engine operates. Each of these pistons transfer the energy of combustion, via connecting rods, to the engine crankshaft causing it to spin and create the torque necessary to move the vehicle it is installed in down the road. A cutaway of a Subaru engine showing the pistons and cylinders is shown below.

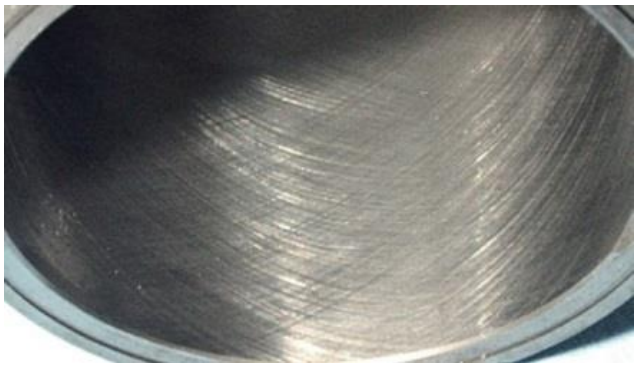


Each of the 4 pistons shown above is equipped with a series of pistons rings. These rings are installed in concentric grooves around the pistons and move with the piston as it reciprocates inside the cylinder bore. An example of an engine piston with the rings installed is shown below.



The primary function of the piston rings is to form a seal with the cylinder bores to prevent combustion gases from passing into the crankcase and crankcase oil from passing into the combustion chamber. This seal results from a process that involves the piston rings wearing into the bore surface shape to form an effective seal between themselves and the bore surface. In order for the piston rings to create this seal between themselves and the surface of the cylinder, the piston rings need lubrication between themselves and the bore surface as they "seat" or mate with the surface of the cylinder bores during the initial operational period of the engine. Once seated, the rings should continue to provide an effective seal between the combustion chamber and the crankcase as long as the necessary amount of lubrication between the rings and the bore surface is maintained.

Lubrication between the piston rings and cylinder bores requires the retention of engine oil on the surfaces of those bores. In order to facilitate oil retention on the bore surface, the surface of the cylinder bores or liners is honed to create a series of grooves, sometimes called a cross-hatch pattern. An example of this groove pattern is shown below.



Cylinder Bore Surface Grooving

These grooves act as oil reservoirs retaining oil up to the top of the groove where it can then spill over onto the surface of the bore to provide a film of oil on which the piston rings can hydroplane as they reciprocate in the bores. If this film of oil is absent or insufficient in providing adequate lubrication between the rings and the bore surface, the seal between the piston rings and the bore surface may be compromised allowing engine oil to pass around the rings and into the combustion chamber where it is consumed during engine combustion.

Engine Oil Consumption
All internal combustion piston engines consume some amount of their own lubricating oil via combustion during normal engine operation. The amount consumed depends on a myriad of factors including vehicle duty cycle, engine age, oil type, oil weight, oil quality, operating conditions, maintenance practices, leaks, internal engine subsystems, component design, climate, environmental factors, etc. As such, there is no "industry standard" for engine oil consumption in passenger vehicles. In fact, many vehicle manufacturers do not publish engine oil consumption figures for the vehicles that they sell.

Obviously an individual engine's oil consumption rate can be affected by the quality, integrity, and longevity of the dynamic seal between its piston rings and cylinder wall surfaces. If that engine experiences a condition such as inadequate seating of the piston rings during break in or accelerated wear of the piston rings during operation, that individual engine may consume noticeably more engine oil during its operation than expected.

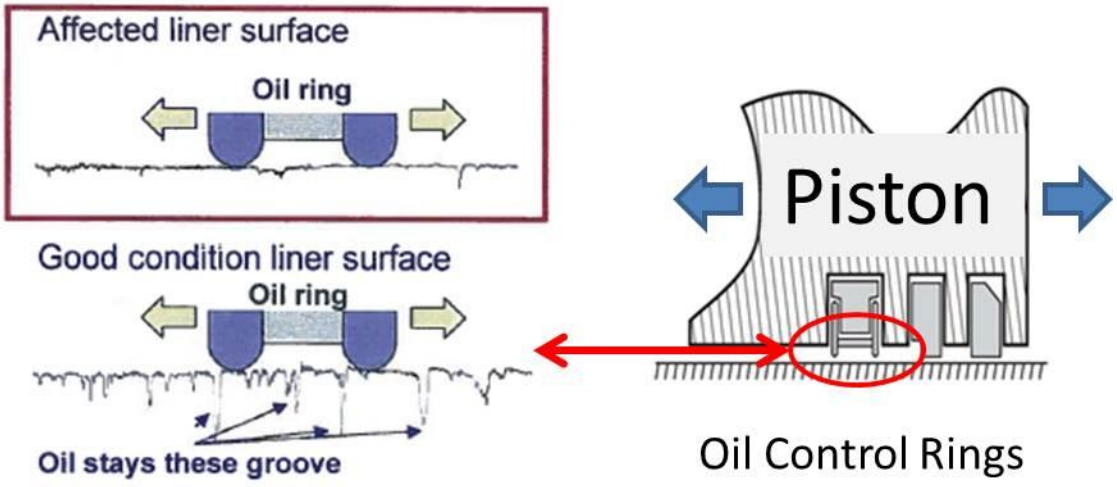
Many factors or more importantly, ***combination of factors***, can affect the integrity and longevity of the piston ring to cylinder bore seal of an individual engine. These can include bore surface finish, engine operating speeds, loads, and temperatures, customer driving style, vehicle application and duty cycle, how the engine is operated during the initial miles of its service life, and even the type of transmission the vehicle is equipped with. Consequently, engine oil consumption within a given group or family of engines can and does vary between its individual members.

FB Engine Countermeasures

The documents reviewed as a part of my analysis outlined several design and manufacturing changes that were incorporated into the FB engine after its initial launch into the North American market in 2010. These changes or "countermeasures" were implemented in response to the engine oil consumption test and repair warranty claims received concerning the FB engine.

Bore Finish and Oil Retention

The roughness of the cylinder bore / liner surface was not retaining sufficient quantities of oil to prevent piston oil ring wear. This condition resulted in enough piston oil ring wear to allow the passage of engine oil past the rings and into the combustion chambers. An illustration of this condition is shown below.

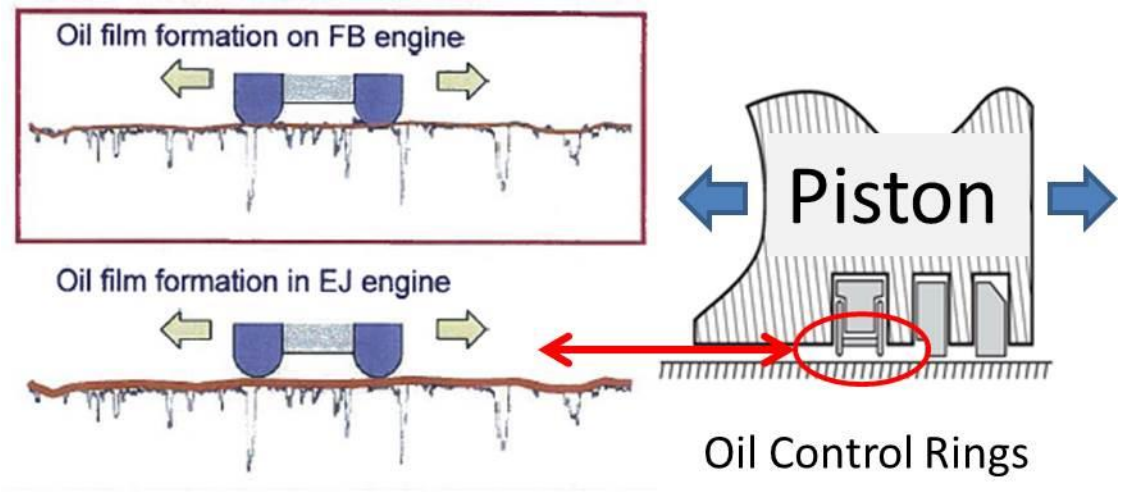


Cylinder Liner Surface Roughness Effect on Oil Retention

Revisions were implemented to provide increased and/or improved cylinder liner surface roughness to improve oil retention and subsequently ring to liner surface lubrication.

Ring Coating and Wear

The oil film formation on the cylinder liner surface of the FB engine was found to be less than anticipated. This condition resulted in increased oil ring wear allowing the passage of engine oil past the rings and into the combustion chambers. The combination of higher cylinder liner temperatures coupled with the use of lower viscosity engine oil was determined to be contributing to this condition. An illustration of this condition is shown below.



Cylinder Liner Oil Film Thickness Effect on Piston Oil Ring Wear

The coating on the cylinder liner contact surface of the oil ring was revised to reduce wear and increase durability. This revision decreased oil ring wear and subsequently oil consumption due to that ring wear.

Ring Design and Manual Transmission Duty Cycle
Subsequent to the above countermeasures, an additional countermeasure was introduced in late 2014 that made further changes to the FB engine piston oil rings. These changes were made to address engine operating conditions specific to vehicles sold in North America with the FB engine paired to a manual transmission.

It is my opinion each of the countermeasures applied to the FB engine was relevant and appropriate. Each countermeasure addressed a root cause issue that was identified as contributing to oil consumption in the FB engine. This opinion is based on my over 31 years of experience designing, testing, evaluating, and developing automotive platforms and their components including engines for passenger cars and light trucks.

Warranty Analysis

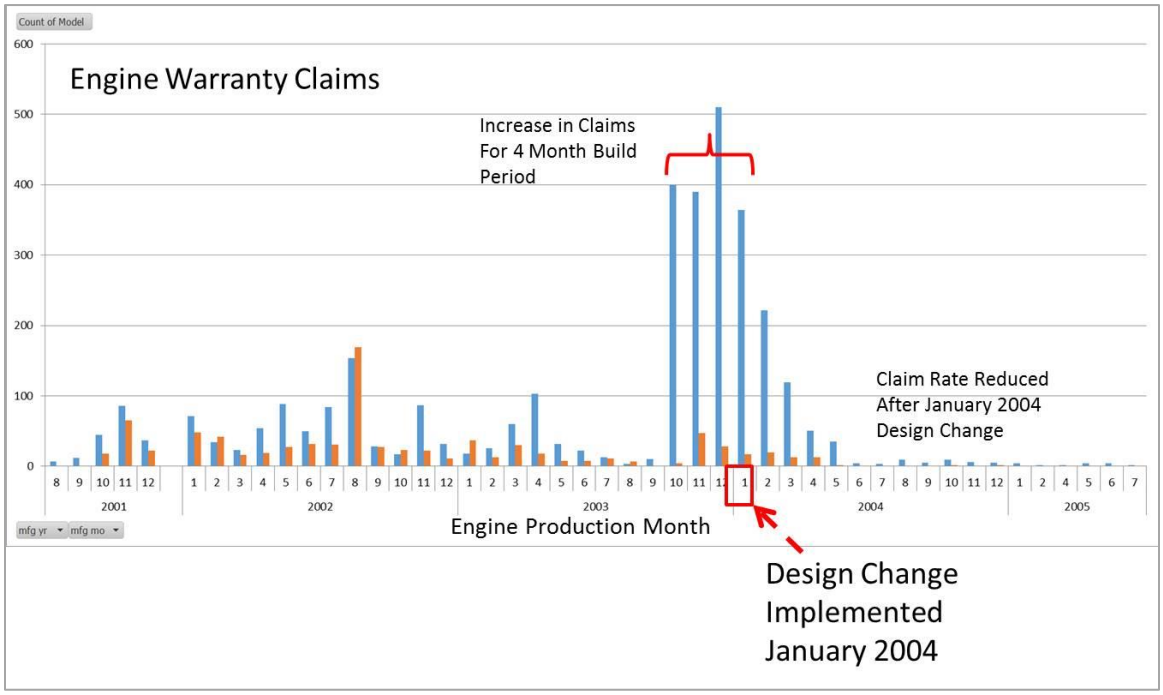
Warranty Repair Claims
Vehicle manufacturer service and warranty repair records are the accurate and accepted source of data used by the National Highway and Traffic Administration (NHTSA) and motor vehicle manufacturers to evaluate and determine the in-use reliability and potential failure rate of the components and systems contained within those vehicles. These records normally include narrative descriptions, vehicle model, model year, engine type, VIN, mileage, in service date, repair date, and other information not necessarily found in other databases.

Although vehicle manufacturer warranty and service repair records are generally limited to those received during the mileage/month limitations of the warranty period, they often

include many additional out of warranty period repair records in the form of factory goodwill repairs and extended warranty contracts. This added information enhances their value and usefulness when evaluating and determining the in-use reliability and potential failure rate of the components and systems within a specific vehicle or engine.

Warranty Trends

Identifying trends in groups of similar warranty service claims is an established and reliable method for determining not only the nature and extent of a warranty issue, but also the effectiveness of any corrective action that may be implemented to address that particular issue. Information such as production dates, build locations, claim mileage, and time in service when the claim occurred are all useful in establishing whether or not an issue is associated with a manufacturing, design, use, or maintenance related issue. Plotting of claims by vehicle build dates can also be done to establish the effect of a specific change, or if a particular issue is isolated to a group of vehicles built at a specific point in time. An ***example*** of such a trend is shown below:



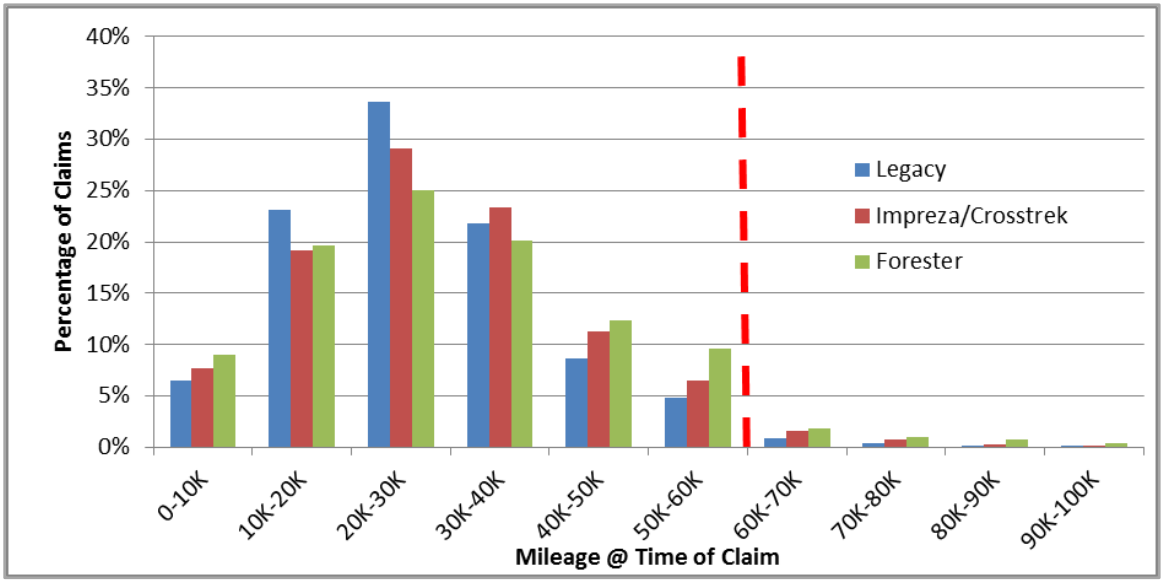
Claim Rates

When reviewing and analyzing groups of warranty claims associated with a particular population of vehicle or assemblies such as an engine, it is important that we determine what portion or percentage of the entire vehicle population these claims represent. This is known as the ***claim rate***. The rate is determined by simply dividing the number of claims by the number of vehicles actually produced. Doing this allows us to accurately determine the extent of a specific warranty issue as a percentage of the total vehicle population, i.e. 0.13% vs. 1.3% of the vehicles produced. Claim rates can also be used to segregate specific groups of vehicles or engines within a given population (i.e. automatic

vs. manual transmission equipped) to determine if the issue occurrence rate varies according to vehicle configuration.

FB Engine Warranty Analysis

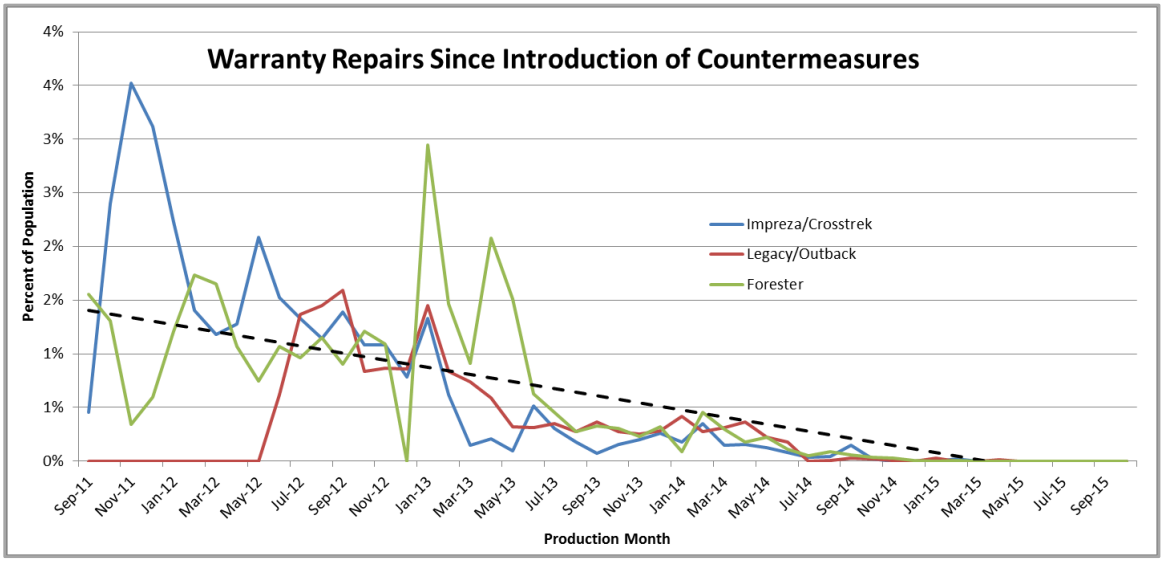
As part of my analysis I reviewed the warranty and service claim records for FB engines related to oil consumption testing and/or repairs performed on those engines. Review and categorization of those claims by vehicle mileage at the time of the claim showed that the majority of claims occurred before the end of the 60,000 mile warranty period and that the claims were on a steady downward trend roughly midway through that warranty period as seen below.



FB Engine Oil Consumption Warranty Claims by Mileage

This type of claim trend is consistent with an "infant mortality" type of condition in which the small percentages of engines that may develop this issue do so relatively early during their service life if at all. These types of issues, by definition, typically affect a specified portion of the subject population early in their service life and do not occur at a later date in the remaining portion of the population.

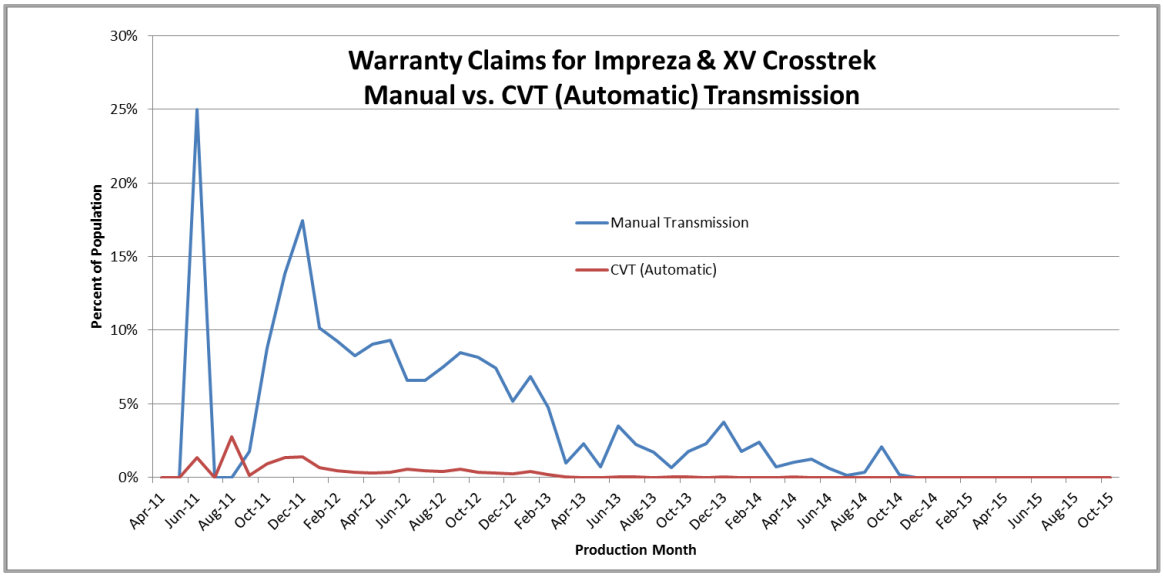
My analysis also included plotting of the repair claim rates by vehicle production dates. This analysis showed a consistent reduction in the oil consumption related warranty repair claim rates as manufacturing and design countermeasures were incorporated into the production of the FB engine. This reduction in engine oil consumption related warranty repair claim rates for the FB engine is shown below.



FB Engine Oil Consumption Warranty Repair Claims by Production Month

Additional plots showing the effectiveness of the cylinder liner surface and oil ring coating countermeasures on automatic/CVT transmission equipped vehicles can be found in attachment *Appendix 1_Countermeasures*. These types of claim trends demonstrate the effectiveness of those countermeasures and the root cause analysis that was performed in response to the FB engine oil consumption warranty claims.

Further analysis of the warranty claims clearly indicated manual transmission equipped vehicles exhibited a higher claim rate than automatic or CVT (continuously variable transmission) equipped vehicles prior to the introduction of the latest countermeasure. An example of this trend is shown in the graph below.



Warranty Repair Rates by Production Month and Transmission Type

What is not obvious from this graph is that for the period shown, the CVT transmission equipped Imprezas and XV Crosstreks represent ***91.7% of the total vehicle population produced while experiencing an average repair rate of only 0.178%.*** Clearly the oil consumption related warranty repair rates for the FB engine were extremely low in the vast majority of vehicles produced i.e. automatic or CVT transmission equipped vehicles. The majority of repair claims were isolated to a minority of the vehicles specifically those equipped with a manual transmission. This trend is evident throughout the FB engine oil consumption warranty claims as summarized and shown in attachment *Appendix 2_Manual Transmission*.

Opinions and Observations

Countermeasures

- The countermeasures applied to the FB engine design and manufacturing process were directly related to the issue of higher than expected engine oil consumption occurring in a minority of the FB engines produced.
- The countermeasures applied to the FB engine piston ring and cylinder bores were reasonable and appropriate changes for addressing the engine oil consumption related claims experienced by that small minority of FB engines.
- The substantial reduction in FB engine oil consumption related warranty claims since the implementation of the countermeasures confirms the efficacy of those countermeasures and the root cause analysis process used to identify and develop them.

Warranty History and Claims

- Review of the FB engine warranty claims before and after implementation of the engine oil level sensing system confirmed that many of the claims did not involve an issue related to excessive engine oil consumption.
- Review of the FB engine warranty claims confirmed that the majority of actual engine oil consumption related issues were occurring relatively early within the warranty coverage period. This is consistent with an early in life or "infant mortality issue"
- Continuous monitoring of the FB engine warranty claims has demonstrated and confirmed the appropriateness and effectiveness of each countermeasure in correcting the issues associated with the prior engine oil consumption warranty claims.
- Current FB engine warranty claims show engine oil consumption related issues to be at a minimal background level.

Summary

- The small number of FB engines which experienced oil consumption issues early in their service life most likely did so either due to oil ring wear or due to lack of an effective seal or "seating" between the piston ring(s) and their cylinder bores.
- The countermeasures that were developed for and applied to the FB engine piston rings and cylinder bores were appropriate and effective in correcting the root cause(s) issues that resulted in increased engine oil consumption by that small number of FB engines.
- The effectiveness of the countermeasures in correcting the FB engine oil consumption root cause issues is evidenced by the steady and measureable reduction in FB engine oil consumption warranty claims back to a typical background level after the countermeasures were implemented into production.

These opinions and observations are provided with a reasonable degree of engineering certainty using currently available data. If additional information becomes available this report may be supplemented as required or appropriate.

Very truly yours,

Robert M. Kuhn P.E.
Managing Engineer
Enclosures (1)